Past and future meet in San Juan Pueblo solar project

Sandia assists with solar oven, solar drying of crops

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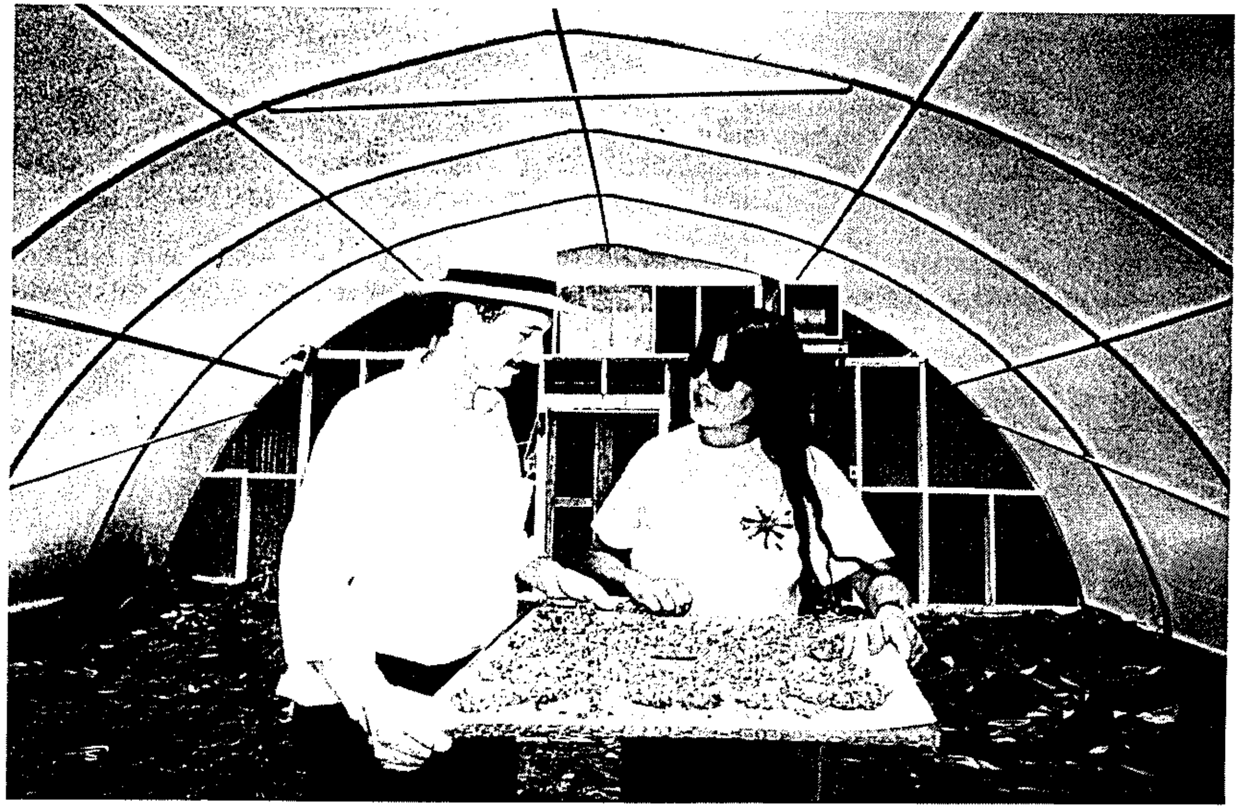
Amid adobe buildings and farmlands nestled in the fertile Rio Grande valley, Indians at San Juan Pueblo in northern New Mexico are using technologies advanced by Sandia to improve traditional methods of food processing and preparation.

Tribal members are using solar power to dry crops quickly for processing and packaging, and a solar oven to bake large quantities of food, including traditional Indian breads. Sandia has provided the pueblo both equipment and technical expertise from its Solar Thermal Design Assistance Center in Solar Thermal Technology Dept. 6216.

"This is a convergence of tradition and technology," says Lynnwood Brown, general manager of the San Juan Agricultural Cooperative, a for-profit association formed in 1992 as a means of bringing pueblo lands back into production. The cooperative is located at the pueblo, about five miles north of Española. "The sun has always been important to the Indian culture; we're just adapting new technology so we can compete in today's economy more effectively."

The cooperative called Sandia for help late last year, and Sandia technicians and engineers immediately began assisting in the design of a solar dehydration system to fit within the pueblo's budget. The large solar oven arrived at the pueblo this spring.

"We immediately viewed this project as a priority because we want to help our neigh-



BERNICE TAPIA inspects dried green chiles with Sandian Dave Menicucci (6216) inside the solar drying facility at San Juan Pueblo. Sandia technicians and engineers helped the pueblo's agricultural cooperative design the solar dehydration system, now used to dry many different fruits and vegetables for packaging.

(Photos by Randy Montoya)

planted acreage to 500 acres within five years.

But bringing fallow land back into production probably would not be financially feasible in itself, Brown says.

Hot trend in food processing

second exhaust fan carries heat to the facility and an adjoining warehouse for comfort during winter months. Propane heaters are used as a backup on overcast days and at night.

The $6,500 solar oven looks like a giant bowl, with shiny reflecting panels that direct

Dave Menicucci (6216). "Our ...ment consists primarily of technical ...sulting — calculations, conceptual ideas, and generally helping them find ways to do it within their budget."

Supplements traditional baking

The cooperative is growing, drying, and packaging a number of different fruits and vegetables, including tomatoes, corn, chile, squash, beans, and melon. The fruits and vegetables are processed and packaged separately, as well as in prepared dishes. The cooperative already has had promising preliminary sales of its packaged green chile stew.

The pueblo is using the solar oven to supplement traditional baking and cooking. Bread routinely is baked in an horno, a free-standing adobe structure that is heated with wood. The solar oven will bake about 54 one-pound loaves of bread per hour, or it can cook large quantities of stews, soups, or other foods. A typical horno can bake about 30 loaves of bread at one time.

The solar oven also can be used to purify contaminated water and sterilize medical equipment in remote areas that lack cooking fuel.

While the San Juan solar agricultural project is showing early signs of success, the true measure will be whether the project makes it economically feasible to bring back into production hundreds of acres of farmland that have lain fallow for decades.

The pueblo has about 2,000 acres of farmland, but only 200 acres are currently cultivated. The cooperative's 40 members have drawn up a business plan that calls for expanding the amount of

"Farming is a relatively high-risk, low-return endeavor," Brown says. "We realized it was absolutely essential to have a product with value added."

That's when the cooperative began looking at food drying, which Brown calls "one of the hottest trends in food processing." He says drying not only preserves food naturally, but enhances its flavor.

The technology used in the solar-drying facility is simple but meets the needs of the cooperative. Sandia consultants advised the cooperative to use the pueblo's existing greenhouse and place it next to the drying and processing facility. When modified with a black plastic floor, the 1,200-square-foot greenhouse reaches temperatures between 120 and 140 degrees F. A large exhaust fan transports heat to drying units in the processing facility, and a

SOLAR-BAKED COBBLER, ANYONE? Arlene Archuletta of San Juan Pueblo holds a cobbler that was baked to a crispy brown in the large solar oven behind her. The traditional horno, a free-standing adobe structure that is heated with wood, is on the left. The solar oven, manufactured by Burns-Milwaukee, Inc., is capable of reaching 400°F and can bake everything from stews to breads to turkeys.

sunlight toward its center. The oven is capable of reaching several hundred degrees F. and can bake everything from stews and bread to turkeys. Burns-Milwaukee, Inc. manufactured the oven, and Sandia's Solar Thermal Design Assistance Center helped perfect and evaluate it. Burns-Milwaukee is loaning the solar oven to San Juan Pueblo, and Sandia paid for the transportation costs.

The solar oven will alleviate the need for firewood, a precious commodity in many remote areas of the desert Southwest. The oven's ultimate success, however, will be how well it is accepted by tribal members since the cultural and traditional aspects of horno-baked bread are strong.

San Juan Pueblo's use of the solar oven will help determine its potential as a supplemental cooking source in developing countries like Mexico.

"The setting at San Juan has many of the traditional qualities that are found in villages in Mexico," Dave says. "This is a good place to test it. Moreover, it's close to Sandia so it's easy for us to stay on top of the situation."

The cooperative has agreed to write periodic reports on the solar oven's use and acceptance.

"The report that the pueblo will produce about the oven will be important to us and how we proceed with the oven in the future, especially regarding other Indian nations and with our Mexican neighbors," Dave says. "We also see the same thing with the solar drying system since the information we accumulate from it also will be important and of great interest to some of our Mexican friends who are interested in doing some similar things."

ESTIMATE OF COLLECTOR SIZE FOR SOLAR DRYING TOMATOES AT THE SAN JUAN AGRICULTURAL COOPERATIVE

The analysis for estimating solar collector size required to dry 160 pounds of tomatoes from 90% moisture content to 12% moisture content was based on a first law thermodynamic approach. The drying time for solar only drying was taken to be 4 days, which compares to what has been reported in the literature on solar drying of various fruits an vegetables.. Presently, the San Juan Coop uses propane gas for drying tomatoes in 44 hours, and requires approximately 25 gallons of propane (2.25 MMBtu) per drying cycle. The actual operation of the drying process would be augmented by solar during the day time hours and the gas heaters would be used during the night time or during the day when poor solar conditions exist. However, for the first cut at this analysis, it was assumed that the heat for drying would be supplied by the solar system. The solar collector used for this system was assumed to be a greenhouse type of collector. The overall process efficiency based on incoming irradiation was assumed to be 40%.

The following approached was used:

- Sensible heat required to raise the temperature of the tomatoes from an ambient air temperature of 60°F to a drying temperature of 120°F.
- Latent heat of evaporating moisture content of the tomatoes.
- Heat required to raise ambient air from 60°F to 120°F. For this time of year (Sept. to Nov.) the average dry bulb temperature is 60°F at an average wet bulb temperature of 44°F. At these stated conditions the relative humidity is approximately 30% at an absolute moisture humidity of 0.004 lb. moisture per lb. of dry air. From information provided by the San Juan Coop, the drying box volume will be approximately 320 ft^3.
- Heat required to raise the absolute humidity of air due to the absorption of evaporated moisture given up by the tomatoes
- An air exchange rate of 1 cfm was used.

Based on this analysis the total heat required for drying is approximately .9MMBtu. This is comparable to the information presented in Solar Crop Drying, CRC, Vol. II. For sizing the collector area, the heat required was set at 1 MMBtu. If all heat for drying is supplied by solar at 40% efficiency, with a drying cycle of 4 days, the required collector area would be approximately 400 ft^2. If solar is to supply only half of the heat with a drying cycle of 2 days, the collector area would still be 400 square feet. Information presented in the CRC for solar augmented drying systems, the optimum percent contribution of solar is about 25 to 30%. This was based on the annual energy cost variation as a function of the solar fraction. If the design is set to a solar contribution of 30%, then the collector area would be approximately 250 square feet. For a drying cycle of 2 days and 100% solar contribution, then 800 square feet of collector area would is required. The following table summaries this information.

Drying Cycle (days)	Collector Area	Required For Various	Solar Fractions
	30%	50%	100%
2	250 ft^2	400 ft^2	800 ft^2
4	125 ft^2	200 ft^2	400 ft^2

Solar insolation data for this analysis was based on the INSOL program using Albuquerque TMY data, but reducing insolation by 10%. Thus, the average daily solar radiation was estimated at 1400 $Btu/ft^2/day$.